

Primer

Maladaptation: When Adaptation to Climate Change Goes Very Wrong

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Adapting to climate change is necessary to ensure that the impacts will not overwhelm societies and ecosystems around the world. But planning adaptation is an exercise in uncertainty, and built on imperfect information, many adaptation strategies fail. Some go even further, creating conditions that actually worsen the situation; this is called maladaptation. Aside from wasting time and money, maladaptation is a process through which people become even more vulnerable to climate change. Poor planning is the primary cause of maladaptation, yet the diverse manifestations are complex, and identifying maladaptation in advance with certainty is difficult. Nevertheless, there is now sufficient experience to give an indication of how maladaptation can take place, the contexts that may be more prone to such an outcome, and the design flaws in strategies that need to be avoided. Until adaptation projects directly address the drivers of vulnerability, however, maladaptation will continue to be a risk.

INTRODUCTION

Climate change is an accepted reality with consequences now and in the future. To address climate change, greenhouse gas emissions need to be reduced, but this will not happen rapidly enough to avoid serious and irreversible damages. The Earth has already warmed by 1°C above pre-industrial levels, and recent scientific evidence suggests that, at the current rate of emissions, warming will hit 1.5°C sometime in the next 30 years. The consequences of this warming include more extreme weather events, loss of health and functioning of major ecosystems, and other biophysical changes that have adverse outcomes on human health, livelihoods, food security, water supply, human security, and economic growth. Because these impacts are already being felt, finding ways to adjust societies to the changing climate is necessary. For example, to address unreliable rain and water scarcity, farmers can harvest rainwater, improve the efficiency of their irrigation systems and switch to less water-intense crops. These *adaptation measures* are often things that farmers already have in their arsenal of strategies to deal with the uncertainty and risk of farming, and the adaptation needs may be mainly about know-how or technology. In other sectors, however, it is necessary to identify new approaches, or change processes altogether. Adaptation to climate change has as a result become an entire area of research and practice, and governments around the world have developed adaptation policies, plans, and programs.

Designing adaptation strategies to ensure changes to the climate do no or only minimal harm may seem straightforward enough. In the worst case, they will be ineffective and a waste of financial resources, right? Actually, no. Poorly designed adaptation strategies can result in *malaadaptation*, where exposure and sensitivity to climate change impacts are instead increased as a result of action taken. Malaadaptation is thus not just a waste of time and money; it is when an action results in conditions that are worse than those which the original strategies were trying to address. Malaadaptation is therefore not being poorly adapted to climate change;

it is actually a process whereby people become even more likely to be negatively affected by climate change. Although decision makers and practitioners are aware of the need to avoid malaadaptation, historically the science of malaadaptation has been generally ineffective when it comes to identifying reliable ways to determine, with certainty, when a specific adaptation strategy is heading down an undesirable route. Today, however, we have sufficient experience, with both development and adaptation projects, to provide at least some indication of scenarios in which malaadaptation can take place, the institutional and actor arrangements most susceptible to malaadaptation, and strategy design flaws to avoid.

THE CHALLENGE OF ADAPTING TO CLIMATE CHANGE

Decades of dealing with the impacts of disasters have taught us that, while humans have some ability to absorb and recover from extreme weather events, losses and damages can set economic and social development back years—even decades. As a result, there is an acknowledgment that strategic and deliberate measures need to be taken to ensure that human societies can progress despite climate change. With this in mind, human adaptation has been defined as a process involving changes and choices that seek to protect individuals and societies from adverse effects of climate change, to allow them to function and attain wellbeing under changing climatic conditions. This refers both to experienced climate change, as well as to anticipated future changes. A good example of an adaptation strategy in the case of flooding is from Bangladesh, where chickens kept for eggs and meat were replaced with ducks, who, unlike chickens, can swim during floods, since people kept losing their poultry when it would flood. This livestock switch is now in fact becoming common in the low-lying flood-prone country.

But there are many uncertain dimensions to climate change that make the outcome of responses to impacts—whether planned deliberately, or actions that develop organically in reaction to the impacts—difficult to predict. For example, if people



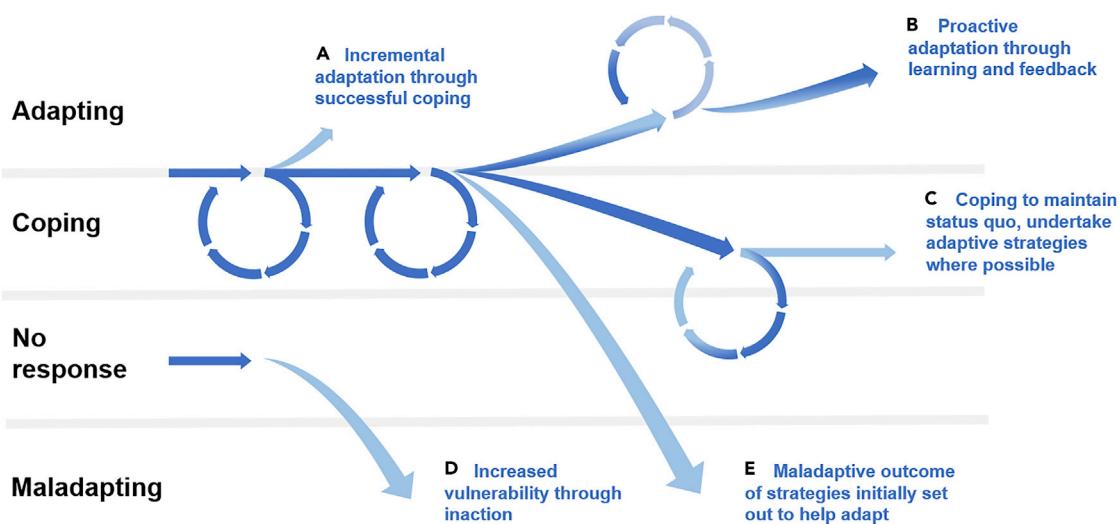


Figure 1. A Conceptual Diagram of Adaptation Outcomes over Time, Including Maladaptation

Coping strategies are short-term actions that help people get through a difficult time, usually undertaken with a belief that the “normal” situation will soon return.

Coping strategies are usually high-cost and can become maladaptive over time if the situation does not improve. The figure describes different outcomes.

(A) An adaptation strategy can start out as a coping strategy focused on the short term, but then build resilience incrementally, so that it eventually leads to positive adaptation.

(B) An adaptation strategy can go through incremental stages of effectiveness, but then succeed based on learning.

(C) A coping strategy with short-term implications can be applied several times without allowing people to adapt fully, but also without making them more vulnerable.

(D) No response to a changing climate will eventually lead to increased vulnerability to climate change and can be considered maladaptive.

(E) Strategies that start out to adapt or coping can become maladaptive over time.

Adapted from [Singh et al \(2016\)](#).

are relocated from coastal areas to avoid being flooded or affected by storm surges, these hazards will no longer pose a threat; however, if they are fishers their coastal access may be constrained, resulting in the inability to keep a protective eye on their boats and fishing equipment, with adverse impacts on incomes and livelihood security. Or if people are given money to rebuild their homes after an extreme storm, they may decide to continue living in the rubble and use the money for other things, such as purchasing new livestock or a vehicle.

The challenge with studying and understanding adaptation is that it is a *process* as much as it is an *outcome*. This is because the climate continues to change, with some known but significantly more unknown consequences for natural and human systems. Furthermore, multiple factors aside from climate influence how effective an adaptation strategy can be, many of which are also changing over time, such as the global economy. As a consequence, if farmers in increasingly dry areas seeking to move away from thirsty cash crops, such as sugarcane, rice, wheat, or cotton that have reliable markets, toward drought-tolerant crops, such as sorghum and millet, this can be a costly and time-consuming investment that may initially hold promise, but potentially fail as a result of market volatility and diet trends. This can be seen in Figure 1, where an adaptive strategy can become maladaptive over time.

As a consequence, determining whether a specific adaptation strategy has been effective or even whether it has been a complete success is often difficult. Against this backdrop, the discussion on maladaptation has been unable to draw strict and definitive lines around the process that translates adaptation into maladaptation. Yet the concept is still important because it speaks to the constant need to assess human behavior, expectations, and understand-

ings of risk. In addition, maladaptation is a reminder that managing how humans relate to the environment around them is challenging and that, as a result of imperfect knowledge, choices and decisions can lead to adverse outcomes. Finally, maladaptation matters because it raises awareness of the multitude of different actors who are “doing” adaptation, including both those who are designing and implementing strategies, as well as those who are the supposed beneficiaries of the strategies. It draws our attention to unequal power balances that exist within this system, and the extent to which the factors that determine vulnerability to climate change in the first place continue to be perpetuated through badly designed adaptation strategies, resulting in maladaptation.

MALADAPTATION AT ONE END OF A SPECTRUM OF RESPONSES

Adaptation to environmental change first appeared in the academic literature in the middle of the last century, but only became a subject of study in the context of climate change in the 1990s. It was contained in a small group of scholars but had a breakthrough when negotiations on the UN climate change convention stalled as countries battled over details around greenhouse gas emissions reduction strategies in the early 2000s. With unclear prospects for stopping climate change, it emerged as a more serious threat to society, and the need to adapt to the impacts it would cause was thrust into the mainstream. Until that point, scientists had mainly taken a theoretical approach to studying adaptation, among other things describing how adaptation could occur through identifying typologies. These differentiated, for instance, between *planned* adaptation driven by explicit plans, such as

zoning for urban development to prevent people from living in floodplains, and *autonomous* adaptation, a more organic response driven by people who were adapting, such as farmers independently switching to different crops in response to drier weather. Other distinctions include temporal and spatial dimensions, including whether a strategy is considered short term or long term, proactive or reactive, or localized or widespread. While the general understanding of adaptation has advanced significantly with a new generation of work on adaptation typologies, the attributes around which they are based continue to be a crucial focus of research. In particular, effectiveness (weighing costs, effort against outcome) and feasibility (financial, institutional, socio-cultural) of adaptation strategies receive significant focus, but this work is still in its infancy. While they are theoretically logical, most of these attributes are difficult to identify on the ground.

Crucially, maladaptation cannot be understood properly without an explanation of vulnerability to climate change. Vulnerability refers to susceptibility to being harmed by climate change. Vulnerability is not an inherent characteristic that people are born with, but rather a filter that is created by social and cultural norms, physical and ecological contexts, and economic biases. Importantly, there are few blanket statements that can be made about who or what is vulnerable to climate change. For instance, poverty is not always equivalent to vulnerability to climate change, because the poor often have more experience with hardship and therefore have more survival strategies at hand, even though they do not have ability to buy resources or services that would help them avoid being affected by a given weather event. Thus, such broad generalization is unhelpful as vulnerability can only be fully understood if it is unpacked by looking at the so-called “root causes.” These factors run deep and contribute to systemic inequalities often driven by historical power struggles and imbalances. The way society constructs race, ethnicity, poverty, political affiliation, and gender can create conditions that mean that a natural hazard can quickly turn into a disastrous event for those who are placed into these categories. To illustrate, studies (e.g., Bradshaw and Fordham, 2013) describe how women in Bangladesh get caught at home during floods and unable to escape to higher ground because socio-cultural norms dictate that they are not allowed to leave their houses without being accompanied by a male relative.

There are many possible outcomes of adaptation strategies, but these are often unable to address the root causes of vulnerability, such as gender norms. When things go really wrong, the outcome is that vulnerability to climate change is increased: this is maladaptation. The way this term is used is variable, and there are at least three ways in which it is used across policy, practice, and science, as described below.

Rebounding Vulnerability

The most accepted definition of maladaptation is when an adaptation strategy aimed at a group of people actually makes them more vulnerable to climate change than they were before. This has been described as “rebounding vulnerability”; i.e., the vulnerability returns (in the same or different form). An even more specific use suggests that such an outcome could also undermine opportunities for future successful adaptation, including creating barriers for sustainable development. This could include a strategy that encourages farmers to sell their land and become employed in another industry that is equally sensitive to climate change impacts but gives

a wage and in the short term offers more security. But it can be maladaptive as it leaves farmers no option to return to farming when the other industry is affected and jobs are cut.

Shifting Vulnerability

Another use of maladaptation is when an adaptation strategy redistributes vulnerability so that others who were not beneficiaries of an adaptation strategy instead become more vulnerable to climate change than they were before the strategy was implemented. For example, when people upstream develop irrigation to address water insecurity resulting from climate change, and take more water out of the river, this leaves less water available for the people downstream. This has been called “shifting vulnerability.” Others have also described maladaptation when a strategy to reduce greenhouse gas emissions or address other development needs ends up making people more vulnerable to climate change. For example, a forestry project in Cambodia was implemented to secure carbon credits, yet the approach included replacing diverse natural forest with acacia plantations, preventing local residents from using the forests in traditional ways. Although the project employed large numbers of local workers, once complete employment was terminated, it left people uncertain of how to secure their livelihoods.

Creating Negative Externalities

Maladaptation is also used to describe adverse outcomes of projects that introduce new problems, which are not necessarily linked with increasing vulnerability to climate change. For example, in Peru women were given access to microcredit to start their own projects as part of an adaptation strategy, but domestic violence rose dramatically because men were jealous of the women’s success. While this is not a positive outcome, to describe this as maladaptation opens the door for all adverse outcomes to be considered maladaptation and confuses what causes vulnerability to climate change in the first place. Decades of experience with development projects have shown the difficulty of limiting negative *externalities*, that is, the adverse impacts on anyone outside of the beneficiaries of a specific intervention. It would be extremely challenging to design a project that benefitted everyone and had no costs for anyone, anywhere, even though this is always the goal.

Importantly, using maladaptation to describe shifting vulnerability and negative externalities ultimately does not highlight the crucial problem that each adaptation intervention has the potential to backfire on the very people who are supposed to be benefitting from it, which should actually be completely preventable. Nevertheless, drawing lines between different experiences proves to be difficult, and many cases of maladaptation will also have negative implications for people outside the immediate beneficiary group, and can increase vulnerability not just to climate change, but to many other threats as well.

EXAMPLES OF MALADAPTION

To better illustrate what maladaptation looks like, this section describes different examples of maladaptation, drawn from various academic studies, and summarizes ways in which maladaptation can be manifest. This is not an exhaustive list of categories but covers a large number of attempted and planned adaptations in three broad categories of adaptation types: infrastructural, institutional, and behavioral.

Infrastructural Maladaptation

The literature is rich with many cases of maladaptation stemming from coastal areas, which are faced with the need to protect against the effects of sea-level rise, salt-water intrusion, coastal storms, and other consequences of climate change. Different forms of protection ranging from infrastructure, mangrove planting, managed retreat, to adopting a discourse of “living with floods” have been implemented around the world. But most of these choices come with consequences. A case from Fiji demonstrates that seawalls built to protect people from rising sea-levels have actually made those living close to them more exposed to hazards, because they end up preventing stormwater drainage. In part, seawalls and other infrastructure give people a false sense of security and encourage them to remain in places or continue with activities that make them vulnerable to climate change if and when the infrastructure fails. In the studied example, the seawalls also shifted vulnerability to people elsewhere along the coast, because of changes in sediment deposits, and created negative environmental consequences by threatening the health of the marine ecosystem (e.g., [Piggott-McKellar et al, 2020](#)). Another study in Bangladesh examined these measures from a gendered perspective, noting that flood control had numerous negative consequences, including eliminating floodplains that had been an important income and food source, and reducing the nutrients in the soils that resulted from the flood water. But, for women, these measures cut off even more opportunities than for men. Landless, poor women could no longer find food and resources to sell when these flooded areas disappeared, reducing their livelihood security (e.g., [Sultana, 2010](#)).

Institutional Maladaptation

An examination of agricultural climate insurance shows that farmers with insurance change the way they use their land or interact differently with networks that they had previously relied on to reduce the risk posed by climate. These changes include a focus on insured cash crops over drought-resistant subsistence crops, intercropping, or moisture conservation techniques, meaning that the farmers become reliant on the insurance. Furthermore, without the need to weigh the risks of planting different crops on a seasonal basis, farmers are no longer engaging with their previous networks, thereby reducing the overall knowledge base, social capital, and risk awareness necessary to mitigate the uncertainty (e.g., [Müller et al, 2017](#)).

Behavioral Maladaptation

Adapting to climate change involves changes in attitudes and behavior, which is likely more important than physical or institutional changes. The strategy of switching from chickens to ducks mentioned earlier, for instance, is only possible if people accept changing their diets to eat duck eggs and meat. But not all behavioral changes turn out well. A study in northern Ghana looking at how farming communities were responding to climate change shows how farmers were temporarily migrating away from rural areas in search of employment due to the insecurity caused by lack of rainfall. But this strategy, while diversifying incomes and reducing pressure on food reserves, ends up creating labor shortages so that when farming conditions are good, there are not enough people available to ensure a successful harvest. Consequently, the act of migrating makes

farming even more difficult, and changes societal structures introducing new dynamics and challenges (e.g., [Antwi-Agyei et al, 2018](#)).

In sum, adaptation and maladaptation must be seen as a continuum, where the outcomes range from an ideal transformation toward a climate-resilient pathway on the one side, to irreversibly higher vulnerability on the other ([Figure 2](#)). While we have numerous examples of maladaptation around the world, it continues to happen, and the shift between adaptation and maladaptation can be subtle and rapid. Similarly, a strategy can have some positive outcomes but still result in maladaptation.

ADDRESSING MALADAPTION: QUESTIONS AND SOLUTIONS

While there have been some efforts to identify the various trajectories of maladaptation as described in [Figure 1](#), the ability to catch maladaptation before it happens is inherently connected to the challenge of evaluating adaptation. Indeed, some of the key questions that remain for researchers include what qualifies as “successful” adaptation, and in particular when this success can be declared. The many different understandings of the scope and purpose of adaptation are part of the reason that designating when it has achieved its goal is difficult. Just as there is a range of adaptation strategies, there is also a spectrum of maladaptation types ([Figure 2](#)). In particular, if adaptation does not address the root causes of vulnerability, instead only touching on the impacts of climate change, this dissonance in understandings becomes problematic.

One thing that research has been able to determine, however, is a number of ways in which poorly planned adaptation translates to maladaptation. Extensive studies built on the study of development and *mal*development, recognize that when key factors, such as inequality, interconnectedness of development pathways, and dependency on infrastructure or institutional structures, are not factored into designing adaptation strategies, they can fail badly and result in exacerbating these drivers of vulnerability (see [Table 1](#); [Figure 2](#)). One recurring finding is the need to better understand the context of the location or group of people in which an adaptation strategy is implemented, to ensure that strategy actually corresponds with the causes of vulnerability and does not just address the symptoms of it.

Both planned and autonomous adaptation can lead to maladaptation, but for different reasons. The causes of maladaptation in planned strategies appear to be primarily about poor design and sloppy application by outside actors who have funds or project expertise, but little knowledge of the social or ecological contexts of the locations in which they are implementing projects. In contrast, maladaptation occurring in autonomous strategies, where people who need to adapt are the ones making decisions, appears to have more to do with limited information leading to poor choices, lack of support networks to fall back on, and insufficient capacity to undertake new employment or follow through with the strategies. In the former case, the design flaws can mostly be addressed (there will always be imperfect information and uncertainty about the way in which the climate is changing), but addressing the inequitable power dynamics between those implementing an adaptation strategy and the people who are supposed to adapt (so-called beneficiaries) requires particular

Spectrum (Worst to Best)	Target population irreversibly more vulnerable to climate change	Target population more vulnerable to climate change, still fixable	Others adversely affected by strategy	Ineffective Adaptation	Short-medium term effectiveness, no negative consequences in the long term	Long-term positive impact	Transformation to climate resilient pathway
Outcomes	Higher vulnerability to climate change than before, vulnerability new or different Pathway Lock-in based on choices/Future adaptation opportunities in future undermined	Higher vulnerability to climate change than before High opportunity costs High risk of pathway lock-in, but some opportunities to reverse remain	Higher or new vulnerability introduced Limited or no options for addressing new vulnerability	Strategy has negligible positive or negative impact	Impacts of climate change addressed, root causes of vulnerability still remain	Vulnerability to climate change addressed	Root causes of vulnerability addressed through system transformation
Examples	Sell land when value almost nothing due to climate pressures, quit farming to do wage labour in climate-sensitive sector likely to result in loss of employment in the near future	Maintain land but engage in seasonal wage labour elsewhere, missing opportunities to improve farming conditions, making changes to livelihood strategy costly or impossible	Develop irrigation that extends life of farming practices in the location, creates significant water stress downstream leading to new climate change vulnerability		Small-scale irrigation is developed for farmers, but climate change continues to pose challenge for agriculture	Mediation groups with upstream/downstream users are established to help create sustainable quotas for water use, making everyone happy, building social capital	Few or no real-world examples exist – this is an ideal outcome

Figure 2. A Spectrum of Responses from Adaptation to Maladaptation

This spectrum describes how adaptation and maladaptation can have different degrees of success or failure, spanning from transformation to climate-resilient pathway, and ideal outcome of an adaptation strategy, to a situation where the target population is irreversibly more vulnerable to climate change. But some maladaptive strategies may not be beyond repair and may be able to move back into the ineffective or even effective adaptation zone over time (as described in Figure 1). Ineffective adaptation sits at the center, where the outcome is essentially negligibly positive or negative. This figure reflects a snapshot rather than movement in time.

care. This refers to the way in which decision makers and others with funding hold power over beneficiaries, by engaging them in projects that they may not necessarily want, often without allowing thorough consultations or equitable participation in project design.

Research and practice have identified a number of solutions to the types of maladaptive outcomes that can emerge from adaptation projects, some of which are described in Table 1. A large portion of these involve having a better overview of the context into which an adaptation strategy is to be implemented. For example, the tension between different actors can also manifest in confusion about who the intended project beneficiaries are, on occasion leaving those who are the most vulnerable to climate change marginalized from a project. Ironically, they are already so marginalized such that their voices rarely get heard. As described in Table 1, a solution to this would be to pay more attention to who the different actors are; and, from a development actors' perspective, going beyond tried and tested networks to ensure that the most powerful people are not suppressing any voices. Similarly, looking beyond the lifetime of the project is crucial, so that not only secondary but also possible tertiary impacts, at both positive and negative sides of a project, are understood. When adaptation is autonomous, this would involve reflection of the many different possible consequences of decisions, some of which may be irreversible.

CONCLUSIONS

Maladaptation is when adaptation to climate change goes beyond wrong. A number of slightly varying understandings of this term exist. At the heart is the idea that maladaptation is an

unexpected and unwanted outcome of an adaptation strategy that is originally implemented with good intentions. With growing experience of adaptation on the ground, it has become clear that poorly designed adaptation strategies are often the drivers of maladaptation. However, there are a number of ways in which these flaws can materialize, and they cannot always be known in advance. They include not being aware of what drives vulnerability to climate change in the first place, putting emphasis on the wrong actors, not understanding the wider development context, and investing in infrastructure or other semi-permanent changes that can lead to lock-in effects.

Over the last decade, experience with implementing adaptation has become widespread, and the study of these experiences have also followed suit. Researchers and practitioners are starting to get a better picture of what can define the limits to adaptation from physical, social, financial, and emotional perspectives. Similarly, they are slowly beginning to grasp how one might define adaptation success. At the same time, the uncertainty of how climate change will affect ecosystems and human societies means that every strategy carries a certain degree of risk. In early days of adaptation scholarship, the ideas of "win-win" or "no-regrets" adaptation strategies were heralded as guiding principles, but over time it has become clear that responding to climate change is complex, and rarely is any strategy only positive. Adaptation strategies need to be embedded in and consistent with development efforts; however, many development trajectories are heading toward unsustainability, making this alignment impossible. Consequently, until vulnerability reduction is at the heart of adaptation measures, the risk of maladaptation will continue to linger.

Table 1. Different Manifestations of Maladaptation and Possible Solutions

Possible Maladaptive Consequences	Problem	Potential Solution
Planned Adaptation		
Exacerbation of existing vulnerability drivers; introduction of new vulnerability drivers	Not understanding what drives vulnerability to climate change and not addressing it in an adaptation strategy, or implementing a strategy that opens the door for these drivers to thrive or spread	A better assessment of what causes vulnerability to climate change among the beneficiaries, as well as a better overview of different pressures in their lives, which may become drivers of vulnerability when new strategies are implemented
Unintended groups are inadvertently beneficiaries People who should have been beneficiaries become even more marginalized, and vulnerable to climate change	Not recognizing the right actors: either the ones who are in need of adaptation or the ones who are behaving in a way that is making a situation worse for another group	Developing projects with attention to actors to ensure that existing partner networks do not exclude the most vulnerable people; ensuring that the most powerful people are not put in a position to marginalize the most vulnerable even more
Exacerbation of existing vulnerability drivers; introduction of new vulnerability drivers; adaptation strategies become ineffective or go counter to other development trends or choices	Not understanding the wider drivers of development	Thorough assessment of development contexts to ensure that adaptation strategies are in harmony with them; assessment of the root causes of vulnerability to determine how they relate to development drivers or barriers
Lock people into development pathways that can prevent them from adapting to climate change impacts in the future, such as cutting off access to certain resources; create incentives for people to settle in areas that are only temporarily safe, such as flood embankments; false sense of security	Investing heavily in infrastructure or permanent land use changes; reduced soil nutrients due to lack of flood water/nutrient replenishment; high opportunity and/or sunk costs	Assess the longevity and long-term costs and consequences of large environmental changes; assess the primary, secondary, and tertiary negative externalities associated with infrastructure projects on both ecosystems and humans
Autonomous Adaptation		
Opportunities for future adaptation and sustainable development are reduced or eliminated because of the lock-in effect of the choices made	Adaptation strategies are implemented for their short-term benefits, such as migration or selling of assets	Ensure that poverty and capacity gaps are addressed so that people have more options and are less likely to make bad choices that determine their future pathways
Opportunities for adapting within existing livelihood strategies become limited; alternative livelihoods may hamper prospects for future development	Adaptation strategies are implemented for their ease of access, desire for cash incomes, or a lack of skills to otherwise diversify, such as abandoning farming to begin wage labor	Ensure a diversity of livelihood options, including training and skills development, through equitable development to avoid people falling prey to middlemen who are looking for cheap and dispensable laborers

Source: Author, based on examples described in the literature listed in Recommended Reading.

RECOMMENDED READING

- Antwi-Agyei, P., Dougill, A.J., Stringer, L.C., and Ardey Codjoe, S.N. (2018). Adaptation opportunities and maladaptive outcomes in climate vulnerability hotspots of northern Ghana. *Clim. Risk Management* 19, 83–93.
- Barnett, J., and O'Neill, S. (2010). Maladaptation. *Glob. Environ. Change* 20, 211–213.
- Bours, D. (2014). Musings on maladaptation, and how to measure it. Earth-Eval blogpost <https://www.eartheval.org/blog/musings-maladaptation-and-how-measure-it>.
- Bradshaw, S., and Fordham, M. (2013). Women, girls and disasters—a review for DFID. <https://gsdrc.org/document-library/women-girls-and-disasters-a-review-for-dfid/>.
- Caldas, A. (2016). Planning Failures: A Story of Unintended Consequences (Union of Concerned Scientists blogpost). <https://blog.ucsusa.org/astrid-caldas/planning-failures-a-story-of-unintended-consequences>.
- Ford, J.D., Berrang-Ford, L., Lesnikowski, A., Barrera, M., and Heymann, S.J. (2013). How to track adaptation to climate change: a typology of approaches for national-level application. *Ecol. Soc.* 18, 40.
- Jones, L., Carabine, E., and Schipper, E.L.F. (2015). (Re)Conceptualising maladaptation in policy and practice: towards an evaluative framework. PRIZE Working Paper. <https://doi.org/10.2139/ssrn.2643009>.
- Juhola, S., Glaas, E., Linnér, B., and Neset, T.S. (2016). Redefining maladaptation. *Environ. Sci. Policy* 55, 135–140.
- Magnan, A., Schipper, E.L.F., Burkett, M., Bharwani, S., Burton, I., Eriksen, S., Gemenne, F., Schaar, J., and Zier vogel, G. (2016). Reframing maladaptation to climate change. *WIREs Clim. Change* 7, 646–665.
- Müller, B., Johnson, L., and Kreuer, D. (2017). Maladaptive outcomes of climate insurance in agriculture. *Glob. Environ. Change* 46, 23–33.
- Piggott-McKellar, A.E., Nunn, P.D., McNamara, K.E., and Sekinini, S.T. (2020). Dam(n) seawalls: a case of climate change maladaptation in Fiji. In *Managing Climate Change Adaptation in the Pacific Region*, Climate Change Management, W.L. Filho, ed. (Springer), pp. 69–84.
- Singh, C., Dorward, P., and Osbahr, H. (2016). Developing a holistic approach to the analysis of farmer decision-making: implications for adaptation policy and practice in developing countries. *Land Use Policy* 59, 329–342.
- Sultana, F. (2010). Living in hazardous waterscapes: gendered vulnerabilities and experiences of floods and disasters. *Environ. Hazards* 9, 43–53.
- Work, Rong, C.V., Song, D., and Scheidel, A. (2019). Maladaptation and development as usual? Investigating climate change mitigation and adaptation projects in Cambodia. *Clim. Policy* 19 (Suppl 1), S47–S62.